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CLEANING WITH ULTRASOUND AND CLEANING AGENTS SUITABLE FOR THIS

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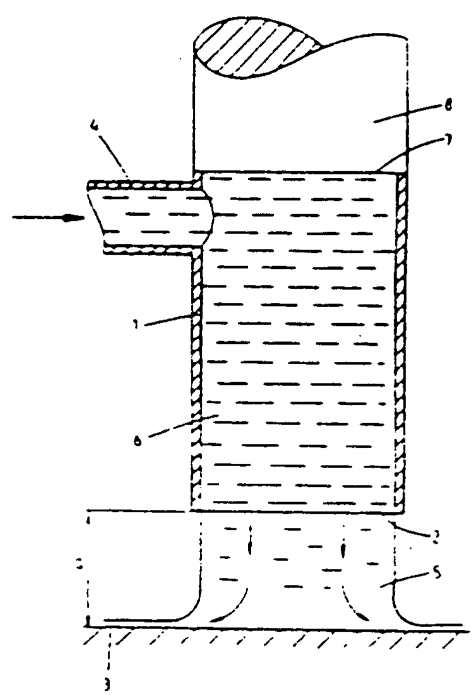
Abstract

The invention concerns a process for cleaning workpiece surfaces (3) using ultrasound and a cleaning fluid (6). According to the invention, the ultrasound oscillations are coupled via the cleaning fluid (6) to the surface (3) to be cleaned. The cleaning fluid (6) is allowed to flow in a targeted jet onto the surface (3) to be cleaned, and the ultrasound oscillations are simultaneously coupled into this jet. This process is very easy to carry out, is not complicated and has a good cleaning effect.



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The invention concerns a method for cleaning the surface of workpieces and components or for removal of fluxing agents using ultrasound and a cleaning liquid. Here the ultrasound vibrations are coupled to the surface to be cleaned through a freely flowing cleaning liquid.

Methods for cleaning hard surfaces using ultrasound, for example, cleaning small parts in the optical and precision mechanics industry have been known for a long time. All kinds of soils and particles, for example, metal filings, grinding and polishing agent residues, turning and milling shavings, as well as oil, grease and paint layers can be removed by means of ultrasound.

The known cleaning methods are carried out in two variations. In the so-called one-pot method the part to be cleaned is put into a bath filled with the cleaning liquid and ultrasonic vibrations are imparted to the cleaning liquid. The ultrasound generators are mounted on the outer wall of the cleaning bath or within the bath.

In the continuous method the material to be cleaned is carried into the cleaning bath by means of conveyor devices, precleaned, irradiated with ultrasound, post-cleaned, dried and then removed or discharged. The cleaning bath itself is essentially equipped in the same way as in the one-pot method. However, frequently the bath liquid is additionally circulated in the opposite direction as the material being cleaned by means of a cleaning agent pump.

In addition, an ultrasound head with which the ultrasound vibrations can be coupled to the object to be irradiated via a liquid stream coming of a small tube is known from a different area of application from the cleaning method (Jochen Matauschek,

Einführung in die Ultraschalltechnik [Introduction to Ultrasound Technology], second edition, 1961, VEB Verlag Technik, Berlin, p. 455). This concerns a part of an apparatus for microscopic observation and irradiation in animal tests. The liquid, in this case a physiological salt solution, flows laterally into a conically tapering tube and then out at the narrow end of the cone. The vibrator, an ultrasound generator, is mounted at the wide end.

A flowing water coupling of ultrasound to a object to be irradiated of this kind is also known from the area of ultrasound material testing (op. cit., p. 348). In this kind of water a jet coupling the ultrasound is transferred to the test piece via a powerful jet of water without any mechanical contact with the test piece.

This flowing water coupling of the ultrasound generator to the workpiece to be irradiated has hitherto been used in areas in which very small amounts of liquid and/or reasonable priced liquids, for example, water without additives, are used. In methods for cleaning with ultrasound, however, considerably larger amounts of liquid are used to which, in addition, costly cleaning agents have been added.

The known methods for cleaning with ultrasound have a number of disadvantages. Relatively large cleaning tanks and correspondingly high volumes of liquids are necessary. A replacement of the cleaning agent is costly and troublesome. The cleaning of parts with large surfaces is in general not possible without expensive special structures with very large cleaning baths. The vibrational energy is distributed in the cleaning bath and for this reason cannot act in a concentrated manner on especially highly soiled spots, so that cleaning of workpieces

with individual, highly soiled places requires an especially long cleaning time. The contaminants that are dissolved away by ultrasound stay in the cleaning bath with the result that the ultrasound action is affected by solid particles that remain in front of the surface to be cleaned. The same thing is valid for gas bubbles.

To clean individual pieces of systems it is necessary to disassemble them. Above all this is true for parts of larger production systems.

In individual cases ultrasound cleaning with the known methods is not possible at all. As an example one can point to the cleaning of the inner and outer walls of permanently installed pipes.

The invention then has as its task the improvement of the method mentioned above in order to be able to use it in a considerably more flexible way with a reduction of costs and in order to remedy the disadvantages of the known cleaning methods that were mentioned above.

This task is solved in accordance with the invention by the fact that the cleaning liquid is allowed to flow in an aimed jet onto the surface to be cleaned and simultaneously the ultrasound vibrations are coupled into this jet.

In contrast to the known cleaning methods using ultrasound, cleaning baths are not employed here. On the contrary the cleaning liquid hits specific regions of the surface to be cleaned in a targeted fashion and flows off of them, for example, into a collection tank, from which it is optionally pumped back after passing through a filter. The high vibrational energy acting on a small surface can considerably shorten the cleaning time. The contaminants that are taken off as well as gas bubbles

that arise are rapidly transported away, so that the ultrasound vibrations can act effectively on the surface without hindrance by removed particles or gas bubbles. The cost of large cleaning tanks and large volumes of cleaning agents are reduced. A rapid change of the cleaning agent composition is possible. In addition, parts of larger systems can be cleaned without problem on site without prior disassembly. Cleaning in a continuous through operation is also possible.

The method in accordance with the invention is suitable not only for cleaning of parts with large surfaces. Both bulk materials and small parts, whether held in position or not, can be cleaned. Difficult cleaning assignments, for example, cleaning of the inner or outer walls of permanently installed pipes, likewise can be solved without problems. The method in accordance with the invention additionally represents an alternative to power wash applications as well as an alternative to cleaning methods that work exclusively with solvents. In addition the method is suitable for the removal of fluxing agents from electronic components.

The cleaning method in accordance with the invention can be carried out in various versions. In a preferred embodiment of the invention, the free jet method, the cleaning liquid is allowed to flow through a nozzle aimed at the surface to be cleaned and arranged at a distance from it. Here the cleaning liquid advantageously enters the nozzle or a feed tube of the nozzle at the side, and the flow is irradiated in the direction toward the nozzle outlet by an ultrasound generator arranged at the opposite end of the nozzle outlet. The free jet technique is usable for parts of any size and with surfaces that are structured and bent in any way.

Within the scope of the invention alternatively to the free jet method the so-called flow gap method is also possible. Here one allows the cleaning fluid to flow through a tube section aimed at the surface to be cleaned and arranged at a small distance, preferably 2 to 80 mm, from it. In contrast to the free jet method the counterpressure formed as a result of the narrow gap works to counteract the outflow of the cleaning agent, so that, in an advantageous way, a smaller amount of liquid must be put into circulation than in the case of the free jet technique. This variation of the method is to be sure especially applicable for relatively large parts with nearly even surface or a surface with a well defined curve.

In a preferred embodiment of this variation the cleaning liquid enters the tube section from the side, and the stream is irradiated by an ultrasound generator arranged at the opposite end of the outlet in the direction toward the outlet.

If a longitudinally vibrating ultrasound generator is used, in an advantageous variation of the method it is completely or partly surrounded by the flow. Alternatively, it can be provided that the longitudinally vibrating ultrasound generator with its oscillating face forms the closure of the nozzle or tube section at the opposite end of the outlet. Both variations can be used both in the free jet and in the flow gap technique. The advantages of the oscillator around which liquid flows lie in a laminar stream that forms more rapidly. A disadvantage is that the sonic energy is carried away radially (weakening the longitudinal component).

If one desires an especially high sonic pressure acting on the surface to be cleaned, in another advantageous variation in accordance with the invention the ultrasound vibrations are

coupled into the jet with several longitudinal oscillators operating in phase and directed toward the outlet of the nozzle or the tube section. This variation can likewise be used both for the free jet and the flow gap technique.

Focusing of the longitudinal oscillator onto a small, nearly point-shaped area enables especially high cleaning performance.

Not only longitudinal oscillators, but also radial oscillators can be used for realization of the invention. In addition there are fundamentally no limitations imposed on the choice of the nozzle. Thus another advantageous variation of the method is possible within the scope of this invention. Here one allows the cleaning liquid to flow through a slit-shaped outlet and couples the ultrasound vibrations into the stream with a radial oscillator, whose longitudinal axis is arranged in parallel with the outlet. This variation of the method can also be used both in the free jet and in the flow gap technique. In contrast to nozzles or tube sections with round outlets here one obtains a linear working surface, which enables a rapid, complete and effective cleaning of large workpiece surfaces. This variation is preferred for the cleaning of bulk materials in a continuous plant.

Preferably a frequency and an intensity of the ultrasound in the range of 20 to 80 kHz, especially 20 to 40 kHz, and in the range of 10 to 1000 W/cm^2, especially 100 to 400 W/cm^2, are used.

As cleaning agents one may consider, for example, aqueous cleaners or cleaners based on a solvent mixture. If the solvents have low ignition points, security measures for protection against explosion and fire are necessary. For this reason the use of aqueous cleaners is preferred. The composition of cleaners of this kind is in principle known in the state of the art. For the

use foreseen within the scope of the invention one must for this reason take care that the cleaning agents do not develop any disruptive foam and/or disruptive gas bubbles in the ultrasound field.

Aqueous cleaners are especially suitable for dissolving polar soils such as, for example, salt deposits. They can contain, for example, 0.5 to 25 wt% surfactants, up to 40 wt% washing activators and builders, as well as up to 3 wt% defoaming agents. The remainder to 100 wt% then consists of water and other active and auxiliary ingredients. An aqueous mixture of this kind can be used as such or can be diluted with water by a factor up to about 100.

The surfactants can be selected from anionic surfactants, nonionic surfactants, and/or cationic surfactants. Substances that may be considered as ionic surfactants are, for example, alkylbenzene sulfonates, alkyl sulfonates, fatty alcohol sulfates, fatty alcohol ether sulfates, α-olefinsulfonates, α-ester sulfonates, alkyl phosphates and alkyl ether phosphates. Nonionic surfactants can be chosen from ethoxylates and/or of fatty alcohols, alkylphenols, fatty amines, fatty acids and fatty acid esters. Other nonionic surfactants that may be used are alkanolamides, amine oxides as well as sugar surfactants. Alkylammonium or imidazolium compounds such as, for example, laurylmethylbenzylammonium salts, can be considered in particular as cationic surfactants.

Washing amplifiers and builders can, for example, be chosen from silicates, especially metasilicates, borates or also chelating inorganic complexing agents such as, for example, oligomeric or polymeric phosphates, pyrophosphates, triphosphates and cyclic or linear metaphosphates. They are preferably used in

the form of the sodium or potassium salts. In addition, for this purpose one may also use organic chelating complexing agents, which are preferably chosen from the group of polymeric carboxylic acids, hydroxyoligocarboxylic acids, nitrogen-containing mono- or oligocarboxylic acids such as, for example, nitriloacetic acid and ethylenediaminetetraacetic acid, diphosphonic acid, aminophosphonic acid, phosphonooligocarboxylic acids or their anions.

In addition, the builders can be chosen from the group of alkali metal hydroxides, carbonates, carboxylates or alkanolamines.

Alkanolamines additionally act as corrosion inhibitors, especially in combination with boron compounds. Aromatic or aliphatic carboxylic acids or their salts that are soluble at the application concentration can also be used as corrosion inhibitors. Examples of aromatic carboxylic acids with corrosion protection action are benzoic acid, substituted benzoic acids such as, for example, hydroxybenzoic acids as well as cinnamic acid. Preferred as aliphatic carboxylic acids are linear or branched saturated carboxylic acids with 6 to 10 C atoms, preferably caprylic acid, pelargonic acid, 2,2-dimethyloctanoic acid and especially 2-ethylhexanoic acid as well as 3,5,5-trimethylhexanoic acid.

Defoamers or foam inhibitors are preferably selected from the group of fatty alcohols, fatty alcohol polyglycol ethers or mixed ethers. Especially effective defoamers are the addition products of 7 to 12 mol ethylene oxide to fatty alcohols with 8 to 18 C atoms that are end group blocked with an alkyl group with 4 to 8 C atoms.

A concentrate of the following composition can, for example, be used as aqueous cleaner (wt%)

75.0% Water
6.0% Pentasodium tripolyphosphate
1.5% 3,5,5-Trimethylhexanoic acid
4.0% Sodium carbonate
3.0% Sodium cumenesulfonate
3.0% Triethanolamine
4.5% Octanol x 10 EO
2.0% Coconut amine x 12 EO.

The concentrate can be diluted with various amounts of water according to the difficulty of the cleaning assignment. For example, good results are obtained when one dilutes the concentrate in a weight ratio of 1:10 to 1:20 with water.

For the removal of fluxing agents from printed circuit boards, a mixture of 23 wt% water, 60 wt% diacetone alcohol, 12 wt% N-2-methylpyrrolidone, 2 wt% triethanolamine, 2 wt% of a nonionic surfactant (C_{13} alkyl polyethylene glycol ether with 5 ethylene oxide units) and 1 wt% of an anionic surfactant (C_{13-17} alkylsulfonic acid sodium salt) is, for example, suitable.

In the following several embodiment examples of the invention are described in more detail by means of drawings. These are

Figure 1: a longitudinal section through a nozzle working in the free jet mode in a schematic representation,

Figure 2: a lengthwise section through a nozzle with several ultrasound oscillators operating in the flow gap technique,

Figure 3: a lengthwise section through a nozzle with an ultrasound oscillator partly surrounded by the stream,

Figure 4: a schematic perspective drawing of a nozzle with a slot shaped outlet and a radial oscillator in the flow gap technique and

Figure 5: a nozzle corresponding to Figure 4 in the free jet technique.

The nozzle in Figure 1 consists of a tube section 1, whose outlet 2 is arranged at a distance a from the surface 3 to be cleaned. Distance a in this embodiment example is 62 mm. The tube section 1 has a diameter of 40 mm. The cleaning fluid flows through a lateral connecting tube 4 connected at the upper end into the tube section 1, where it is turned, exits as a free jet 5 from the outlet and strikes the surface 3 of the workpiece to be cleaned. The flow rate is set so that a laminar flow results. In some cases it is advantageous if the cleaning agent 6 is heated.

At the upper end 7 of tube section 1 that is opposite from the outlet 2 a rod-shaped longitudinally vibrating ultrasound generator is mounted. In the embodiment in accordance with Figure 1 the oscillator 8 serves at the same time to close off the upper end 7 of tube section 1.

Alternatively, however, it can be provided that the longitudinal oscillator 8 projects partly or completely into the tube section 1, as is shown in Figure 3.

To amplify the ultrasound action a nozzle with more than one oscillator 8 in correspondence with Figure 2 can also be provided. Here the cleaning agent 6 enters through an upper connecting tube 9, in contrast to the embodiments in accordance with Figures 1 and 3. This method operates with the flow gap

technique. In contrast to the free jet technique only a relatively small amount of liquid exits through the very narrow gap 10 between the outlet 2 and the surface 3 of the workpiece. The distance between the nozzle outlet and surface 3 is preferably 2 to 80 mm.

The focusing of the longitudinal oscillators operating in the same phase is indicated by the dash-dot line.

The use of radial oscillators in the method in accordance with the invention is shown in Figures 4 and 5. Figure 4 schematically shows the use in the flow gap technique, while Figure 5 shows the use of radial oscillators in the free jet technique.

Radial oscillator 11 is mounted within a nozzle and parallel to the slit gap 12. Otherwise this variation of the method corresponds to the earlier figures, where, as in the other drawings, the same designations have the same meanings.

The ultrasound cleaning action can be aided by brushes that are present in the water jet and/or in the water flow area and operated mechanically or by the water jet.

Designation list

1	Tube section
1'	Nozzle
a	Distance
2	Outlet
3	Surface
4	Side connecting tube
5	Free jet
6	Cleaning agent

7 Upper end
8 Oscillator
9 Upper connecting tube
10 Gap
11 Radial oscillator
12 Slit gap

Claims

1. A method for cleaning the surface (3) of workpieces using ultrasound and a cleaning liquid (6), where the ultrasound vibrations are coupled to the surface to be cleaned (3) by the cleaning liquid (6), which is characterized by the fact that, the cleaning liquid (6) is allowed to flow in an aimed jet onto the surface (3) to be cleaned and at the same time the ultrasound vibrations are coupled into this jet.

2. A method as in Claim 1, which is characterized by the fact that, the cleaning liquid (6) is allowed to flow through a nozzle (1') aimed at the surface to be cleaned (3) and at a distance (a) from it.

3. A method as in Claim 2, which is characterized by the fact that, the cleaning liquid (6) enters the nozzle (1') from the side or into a connection of nozzle (1') and the flow is acoustically irradiated by an ultrasound oscillator (8,11) arranged at the opposite end (7) of the nozzle outlet (2,12) in the direction toward the nozzle outlet (2).

4. A method as in Claim 1, which is characterized by the fact that the cleaning liquid (6) is allowed to flow through a tube section (1) aimed at the surface to be cleaned (3) and at a small distance, preferably 2 to 80 mm, from it.

5. A method as in Claim 4, which is characterized by the fact that the cleaning liquid (6) enters the tube section (1) from the side and the flow is acoustically irradiated by an ultrasound oscillator (8,11) arranged at the opposite end of the outlet (2) in the direction toward the outlet (2,12).

6. A method as in Claim 3 or 5, which is characterized by the fact that the longitudinally oscillating ultrasound oscillator (8) is fully or partly surrounded by the flow.

7. A method as in Claim 3 or 5, which is characterized by the fact that the longitudinally oscillating ultrasound oscillator (8) forms, with its oscillating face, the closer of the nozzle (1') or tube section (1) at the opposite end from the outlet (2).

8. A method as in one of Claims 2 to 7, which is characterized by the fact that the ultrasound oscillations are coupled into the flow with several longitudinal oscillators (8) operating in the same phase and aimed at the outlet (2) of the nozzle (1') or the tube section (1).

9. A method as in one of Claims 2 to 8, which is characterized by the fact that the liquid (6) is allowed to flow through a slit-shaped outlet (12) and the ultrasound oscillations are coupled into the flow with a radial oscillator (11), whose longitudinal axis is aligned parallel to outlet (12).

10. A method as in one of the preceding claims, which is characterized by the fact that ultrasound in the frequency range of 20 to 80, especially 20 to 40 kHz, is used.

11. A method as in one of the preceding claims, which is characterized by the fact that an ultrasound intensity of 10 to 1000, especially 100 to 400 W/cm^2, with respect to the outlet cross section of the nozzle or the tube section is used.

12. A method as in one or more of Claims 1 to 11, which is characterized by the fact that one uses as cleaning liquid (6) an aqueous preparation that uses 0.5 to 25 wt% surfactants, up to 40 wt% builders and wash activators and up to 3 wt% defoaming agents and as the remainder to 100 wt% water or an aqueous solution of other auxiliary or active ingredients.

13. A method as in one or more of Claims 1 to 11, which is characterized by the fact that one uses as cleaning liquid (6) an aqueous solution that can be obtained by diluting the aqueous preparation mentioned in Claim 12 with water by a factor up to 100.

14. A method as in one or more of Claims 1 to 11, which is characterized by the fact that one uses as cleaning liquid (6) a nonaqueous solvent or solvent mixture.

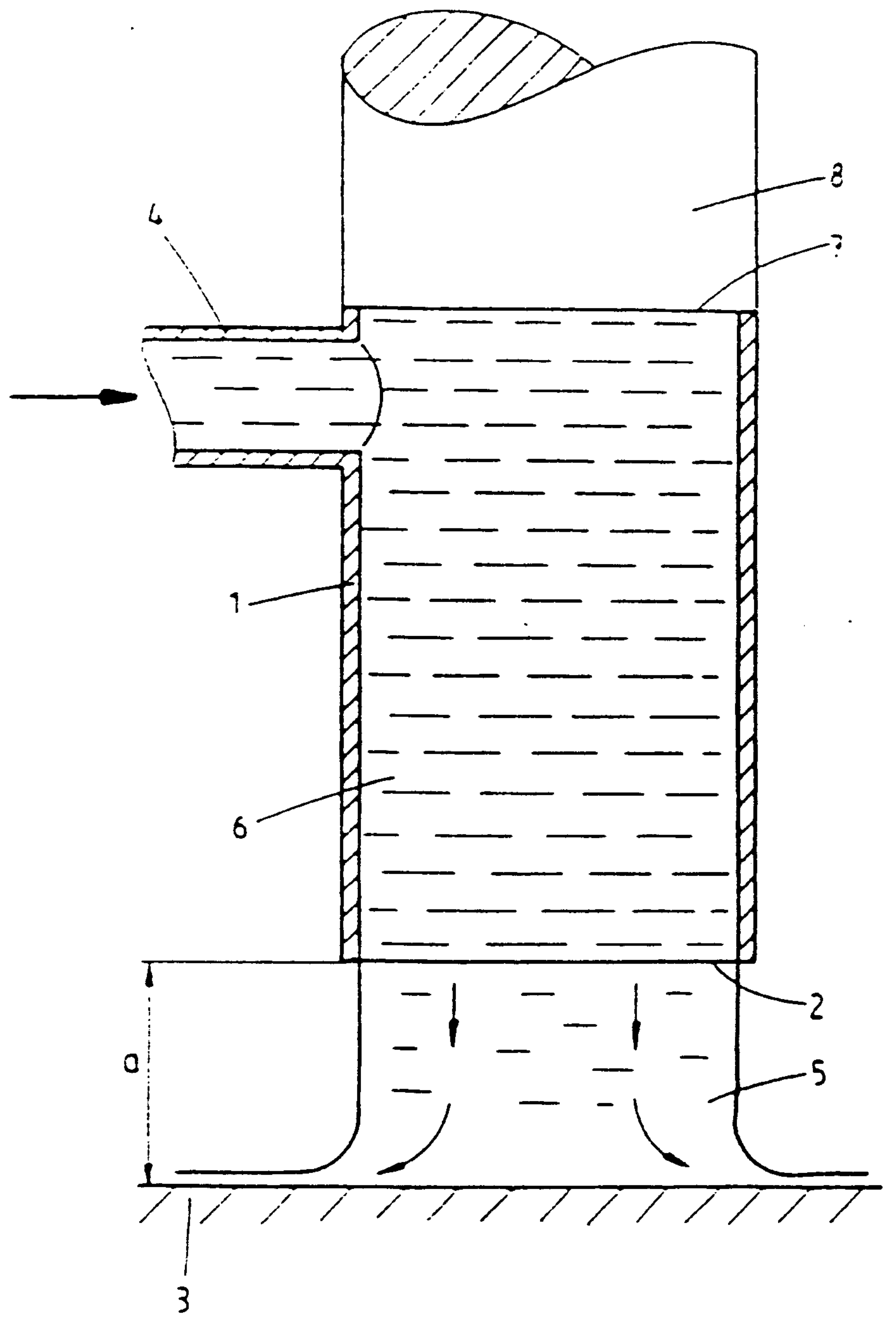

Figure 1

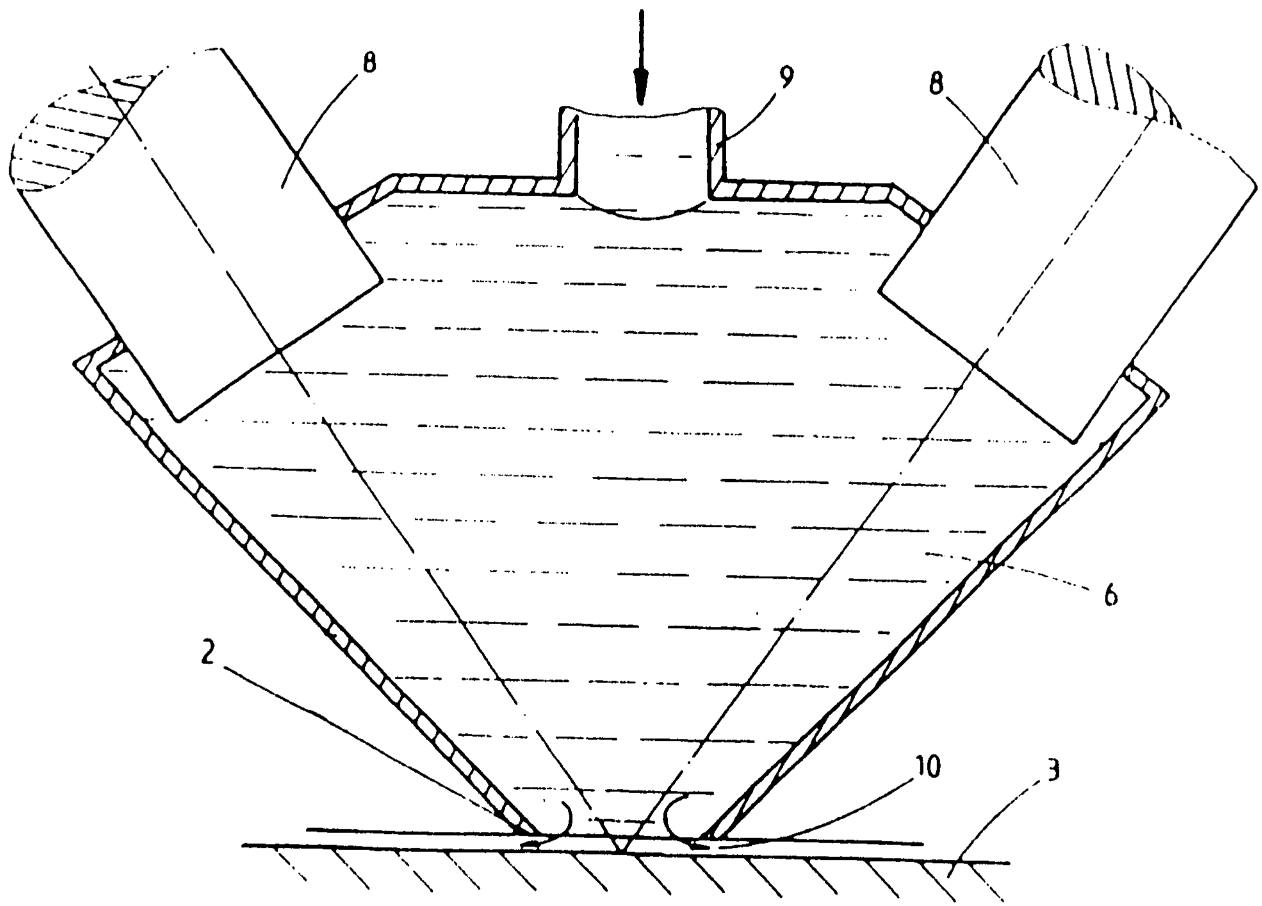

Figure 2

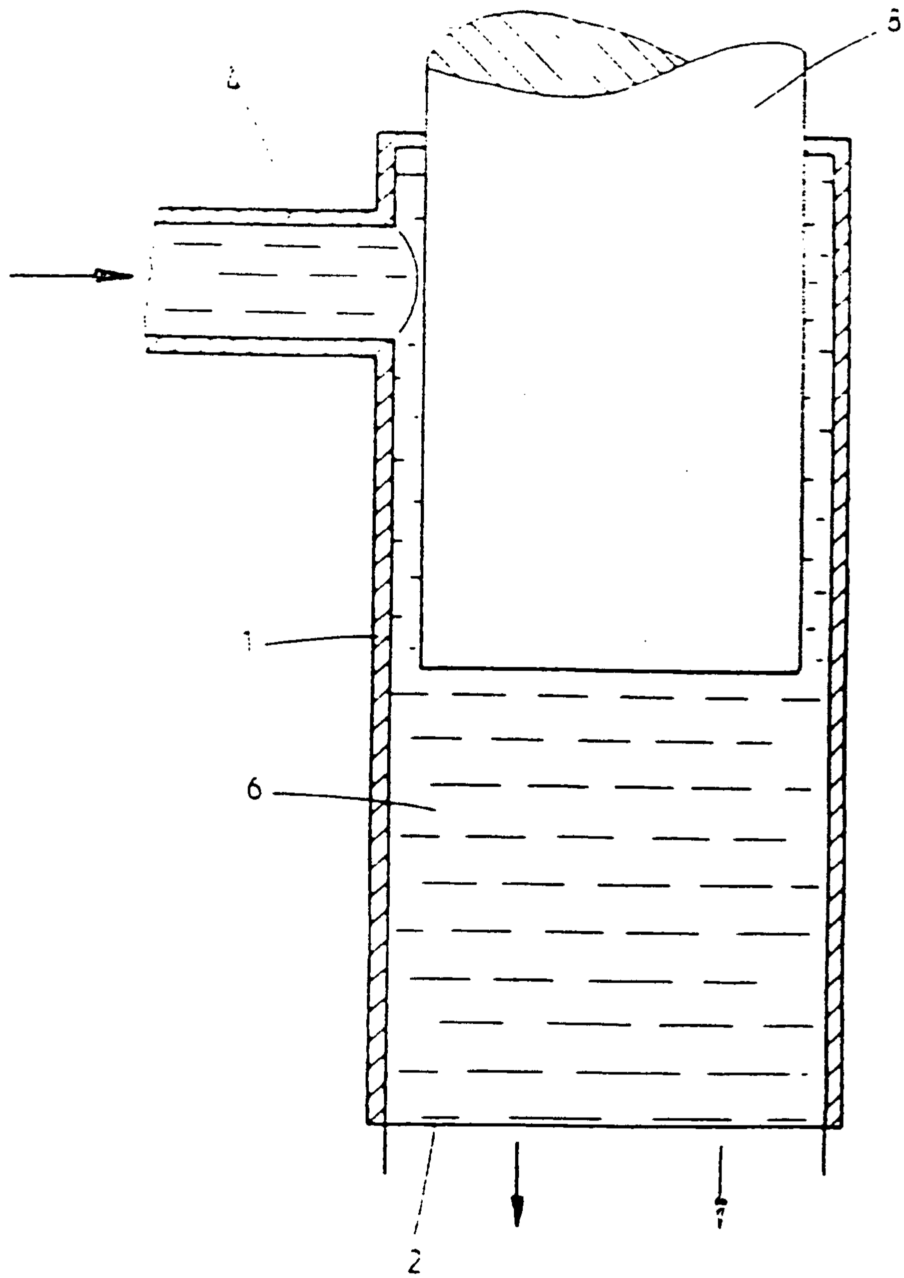

Figure 3

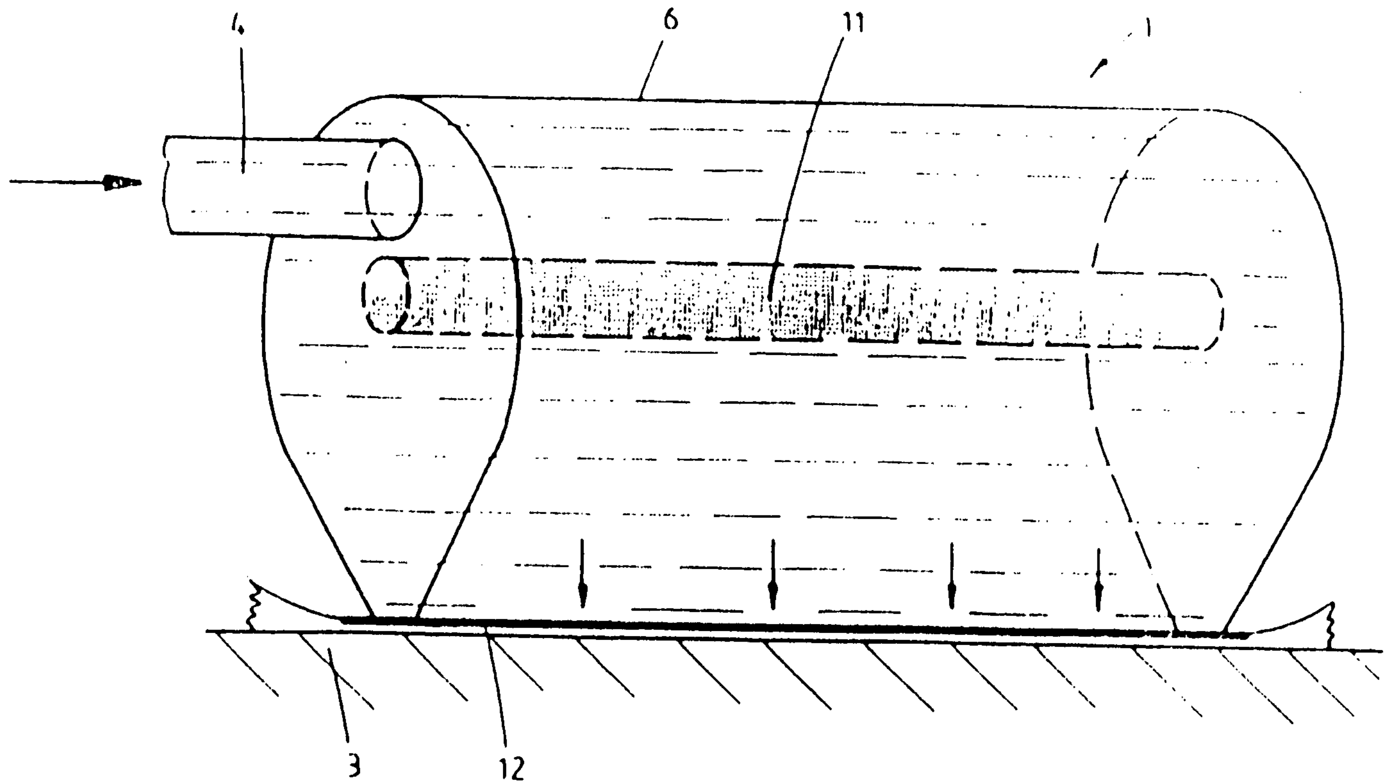

Figure 4

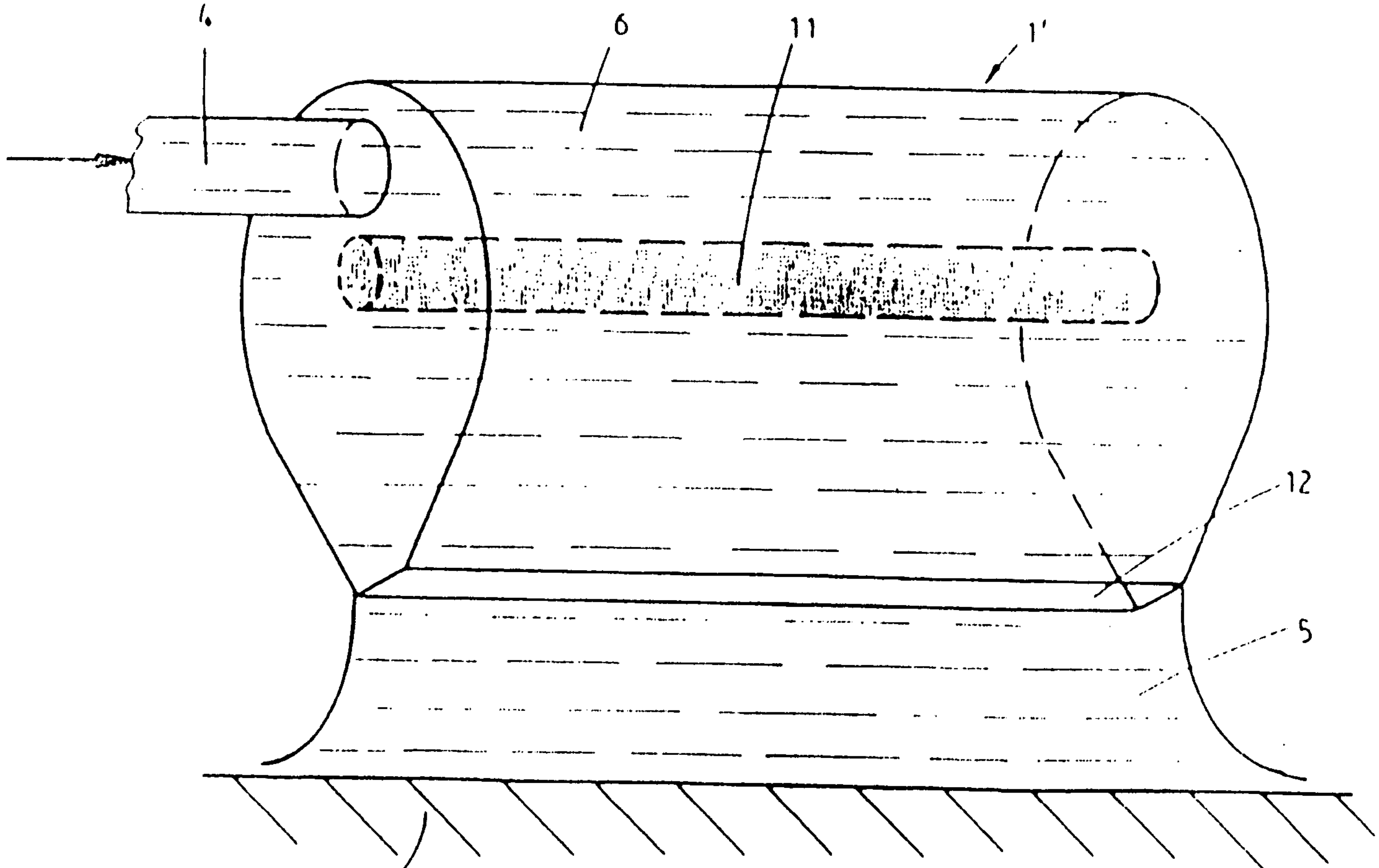

Figure 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 96/04564

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B08B3/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B08B C11D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y		12,13
Y	EP,A,0 241 073 (THE PROCTER & GAMBLE COMPANY) 14 October 1987 see page 1, line 5 - page 2, line 26 see page 5, line 28 - line 34	12,13
A	DE,A,33 39 048 (NEA NUCLEAR ENGINEERING FÜR ANWENDUNGSTECHNIK GMBH) 9 May 1985 see abstract see page 10, line 9 - page 12, line 32	1,6,10, 12,13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 January 1997	18.02.97

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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X	FR,A,978 290 (DECHAUX) 11 April 1951 see page 1, left-hand column, line 1 - page 2, right-hand column, line 5; figures	1-7
A		12,13
X	US,A,4 326 553 (HALL) 27 April 1982 see column 1, line 51 - column 2, line 47; figures	1-7
A		9,11-14
X	US,A,5 368 054 (KORETSKY ET AL) 29 November 1994 see column 3, line 25 - column 4, line 59 see column 8, line 44 - line 53; figures	1-6,8,10
A		11,12
X	US,A,3 373 752 (KIYOSHI INOUE) 19 March 1968 see column 3, line 15 - column 4, line 24; figures	1,2,4, 10,14
A		3,5,6, 11-13
X	WO,A,91 09770 (CADUFF) 11 July 1991 see page 6, line 12 - page 7, line 34; figure 4	1,2,4
A		3,5,8,12
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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 96/04564

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